The Conversion of Dry Roughage into a Succulent Feed

AN EXAMINATION OF THE SUGAR JACK PROCESS

An investigation conducted by

THE DIVISION OF ANIMAL HUSBANDRY
THE DIVISION OF CHEMISTRY
THE DIVISION OF BACTERIOLOGY

CENTRAL EXPERIMENTAL FARM, OTTAWA

DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE
BULLETIN No. 96—NEW SERIES

Published by Direction of the Hon. W. R. Motherwell, Minister of Agriculture,
Ottawa, 1927

DOMINION EXPERIMENTAL FARMS BRANCH

PERSONNEL

DIRECTOR, E. S. ARCHIBALD, B.A., B.S.A.

Dominion Field Husbandman ..... E. S. Hopkins, B.S.A., M.S.
Dominion Chemist ..... Frank T. Shutt, M.A., D.Sc.
Dominion Horticulturist ..... W. T. Macoun.
Dominion Cerealist ..... L. H. Newman, B.S.A.
Dominion Botanist ..... H. T. Güssow.
Dominion Animal Husbandman ..... G. B. Rothwell, B.S.A.
Dominion Forage Crop Specialist ..... G. P. McRostie, B.S.A., Ph.D.
Dominion Poultry Husbandman ..... F. C. Elford.
Chief, Tobacco Division .....
Dominion Apiarist ..... C. B. Gooderham, B.S.A.
Dominion Bacteriologist ..... Grant Lochhead, Ph.D.
Chief Officer, Extension and Publicity ..... F. C. Nunnick, B.S.A.
Chief Supervisor of Illustration Stations .....
Economic Fibre Specialist ..... R. J. Hutchinson.

ALBERTA

Superintendent, Experimental Station, Lacombe, Alta., F. H. Reed, B.S.A.
Superintendent, Experimental Station, Lethbridge, Alta., W. H. Fairfield, M.Sc.
Superintendent, Experimental Sub-station, Beaverlodge, Alta., W. D. Albright.
Superintendent, Experimental Sub-station, Fort Vermilion, Alta., Robt. Jones.

BRITISH COLUMBIA

Superintendent, Experimental Farm, Agassiz, B.C., W. H. Hicks, B.S.A.
Superintendent, Experimental Station, Summerland, B.C., W. T. Hunter, B.S.A.
Superintendent, Experimental Station, Invermere, B.C., R. G. Newton, B.S.A.
Superintendent, Experimental Station, Sidney, B.C., E. M. Straight, B.S.A.

MANITOBA

Superintendent, Experimental Farm, Brandon, Man., M. J. Tinline, B.S.A.
Superintendent, Experimental Station, Morden, Man., W. R. Leslie, B.S.A.

SASKATCHEWAN

Superintendent, Experimental Farm, Indian Head, Sask., W. H. Gibson, B.S.A.
Superintendent, Experimental Station, Rosthern, Sask., W. A. Munro, B.A., B.S.A.
Superintendent, Experimental Station, Scott, Sask., Victor Matthews, B.S.A.
Superintendent, Experimental Station, Swift Current, Sask., J. G. Taggart, B.S.A.

NEW BRUNSWICK

Superintendent, Experimental Station, Fredericton, N.B., C. F. Bailey, B.S.A.

NOVA SCOTIA

Superintendent, Experimental Farm, Nappan, N.S., W. W. Baird, B.S.A.
Superintendent, Experimental Station, Kentville, N.S., W. S. Blair.

PRINCE EDWARD ISLAND

Superintendent, Experimental Station, Charlottetown, P.E.I., J. A. Clark, M.S.A.

ONTARIO

Central Experimental Farm, Ottawa, Ont.
Superintendent, Experimental Station, Kapuskasing, Ont., S. Ballantyne.
Superintendent, Experimental Station, Harrow, Ont.

QUEBEC

Superintendent, Experimental Station, Cap Rouge, Que., G. A. Langelier, D.Sc.A.
Superintendent, Experimental Station, Lennoxville, Que., J. A. McClary.
Superintendent, Experimental Station, Ste. Anne de la Pocatière, Que., J. A. Ste. Marie, B.S.A.
Superintendent, Experimental Station, La Ferme, Que., P. Fortier, Agr.
Superintendent, Tobacco Experimental Station, Farnham, Que., J. E. Montreuil, B.S.A.

TABLE OF CONTENTS

52455—1

The Conversion of Dry Roughage into a Succulent Feed: An Examination of the Sugar Jack Process

An Investigation Conducted by the Divisions of Animal Husbandry, Chemistry, and Bacteriology, Central Experimental Farm, Ottawa, Ont.

With the development of dairying in Canada, more and more attention is being given to methods of preparing farm roughages for dairy cattle. In the early days, cured hay and corn fodder were amongst the feeds commonly used. The need for succulence and increased palatability was met by many feeders, through the adoption of a simple process involving the chaffing of such roughages, moistened with water, or mixed with pulped roots, allowing the whole mass to stand for some hours until thoroughly moistened, softened and warmed as a result of very slight fermentation. This method of preparation, however, gradually gave place to the ensiling process, which provided a much more palatable, nutritious and economical feed, and withal the result of a most practical method of preparing roughages. In latter years, many other crops commonly used as dry roughages, such as sweet clover, red clover, alfalfa, peas and oats, and sunflowers, have become more or less popular as silage crops, particularly where corn can not be grown successfully, thus allowing for the conversion of these coarse, dry roughages into a more palatable, succulent feed, the process proving economical and profitable in the very great majority of cases.

The value of roots, in the ration for dairy cattle, was early recognized; then came the development of the root slicers and pulpers, very necessary machines where roots are fed in large quantities, but of doubtful economy, however, where they are fed in a limited way, as a supplement to a ration already sufficiently well supplied with succulent feed in the form of silage. At the Central Experimental Farm, Ottawa, it has been found that under the latter conditions roots attain their highest feeding value, and under these conditions, too, the average dairy cow is quite well equipped with the necessary appliance to perform her own root pulping most economically.

Still later in the history of dairy cattle feeding there came an agitation in favour of the grinding of coarse, dry roughages, such as corn fodder, red clover hay, sweet clover hay, coarse alfalfa hay, etc., the claim being made that by grinding these feeds fairly minutely, more of the nutrients in the feeds were made available to the animal, through the breaking down of the fibrous parts of the plant, thus allowing the contents of the inner cells of the plants to be acted upon by the digestive juices in the alimentary tracts of the animals. Probably it should be stated, at this juncture, that the agitation in favour of the preparation of dry roughages, by grinding, did not emanate from the farmer or dairyman, as a result of unsatisfactory results from the, then, standard methods of feeding, but rather from machinery manufacturers who had various types of roughage feed grinders for sale. This phase of the dairy cattle feeding problem has been investigated by the Central Experimental Farm with the general result that it has been found that little, if any, benefit accrued from the grinding of coarse roughages for dairy cattle and that any noticeable benefit was more than offset by the added cost of preparation of the feed. The dairy cow, with her four capacious stomachs, her faculty of quickly filling these, then quietly resting and regurgitating or rechewing the food stored therein, is of all farm animals the most economical converter of coarse roughage into concentrated food products. So admirably is she adapted by nature to this purpose,

that her mechanical equivalent has yet to be invented. Consequently it would seem improbable that the grinding of farm roughages for dairy cattle would develop much beyond the present more or less experimental stage. Let it be kept in mind, however, that what has been stated concerning such grinding processes, refers to roughages only and not to the grinding of grains, which undoubtedly has a legitimate place on every dairy farm and has long been considered as a process of well ordered necessity.

The foregoing successive steps lead to one of the latest ideas in live stock feed preparation and with which this publication is mainly concerned, namely, the "*Sugar Jack*" system of feeding.

The following quotations are taken from advertising matter distributed by the Canadian manufacturers:—

"Sugar Jack is the trade name applied to a process of treating all kinds of dry roughage, such as hay, fodder, stalks, vines, straws, etc., to render them succulent and digestible. The process so changes the roughage, physically and chemically, as to make it palatable and almost entirely digestible when consumed.

"Sugar Jack Converter is a trade name applied to a vegetable and mineral compound in powdered form, which when dissolved in water is chemically similar to saliva, gastric and pancreatic juices. The converter solution is used by feeders to moisten roughage in stave tubes leading from the mow to the feeding floor. The roughage digests so rapidly in these tubes, when it is cut ripe or over-ripe and moistened evenly, that the temperature due to digestion rises to from 130 to 185 degrees Fahrenheit, according to the character of the roughage and the equal distribution of the converter solution. The lower end of the stave tube, called a Sugar Jack, is elevated above the feeding floor. As the finished feed is removed from the feeding floor other dry roughage is placed in the upper end of the tube and moistened by the solution of converter.

"In this manner the Sugar Jack tube, termed a Sugar Jack Press, is kept filled and processing continuously. The process requires 48 hours."

"*Advantages of Sugar Jacks.*—The Sugar Jack system of farming and feeding enables farmers to utilize large amounts of hay and fodder crops which yield prolificly with little labour, and also to utilize practically all the by-products of the farm, such as cornstalks, clover threshings, vines and straws. When these advantages to the farmer are considered with the greatly increased digestion of roughage nutrients, as against the minimum digestion under the old method of feeding, the Sugar Jack process appeals to intelligent farmers as a great advantage from the standpoint of increased soil production, as well as increased feeding efficiency. Examination of Sugar Jack manure, based on roughage consumed corroborates the claim that animals thrive on one-half of the roughage required by the old system of feeding."

"The Sugar Jack process restores dry roughage to a succulent state, approximating green pastures—and in addition it saves half the roughage. Dairy farmers who had to buy feed each spring under the old system since using the Sugar Jack process have been able to double their herds and still grow all their feed from the same farm land.

"*Sugar Jack Crops.*—Farm roughage processed in Sugar Jacks must be cut ripe or after the ripened period. During the last week before roughage reaches the ripened point, valuable digestive agents develop which farmers are enabled to use with the aid of Sugar Jack Converter, to produce chemical changes of a profitable nature. This cannot be done with roughage cut prior to the ripened period. If, however, the roughage is harvested one or two weeks after the ripened period, no injury results, and the roughage, if anything, is more valuable cut after the ripening period, one or two weeks, than cut just at the ripened period."

"The process of digestion is due to fermentation. The farmer who ferments his roughage must be as accurate as the wine manufacturer who ferments his grapes. The farmer ferments his roughage to make it possible for his live stock to convert vegetable food into animal food, such as beef, pork, mutton, veal, poultry, milk, eggs, etc.

"*Cut and Uncut Roughage.*—Red clover hay, any kind of clover threshings, and vines need not be cut in making Sugar Jack feed. If, however, red clover hay be mixed with timothy, the processing is much better if the mixed hay be cut. Cornstalks, fodders, sweet clover and timothy should be cut in all instances to obtain satisfactory results. Timothy hay should never be processed by itself, but should be mixed with red or other clovers. Green alfalfa does not process to advantage, but ripe alfalfa processes well.

"Hays which are unpalatable owing to frequent rains, after cutting and before taking to the barn or stack, are made palatable and digestible by the Sugar Jack process. Clover threshings make palatable Sugar Jack feed because the hay for seed is always cut at or after the ripening period. Sugar Jack made from clover threshings, pea, bean and other vines, produces excellent results in milk flow.

"Sweet clover for Sugar Jack is cut ripe, with a binder, shocked and left in the field until thoroughly dry, then stacked or thrown in the mow by an ensilage cutter. Cut hay requires about one-half of the space filled by uncut hay. Cornstalks are usually placed in the mow with hay by an ensilage cutter, or stacked near the barn. Many cornstalks, however, are brought from the fields in the early spring for use up to the time of haying. Sweet clover is satisfactorily stacked in the field whether cut with a binder or otherwise. Sweet clover threshings are about equal in value with red and alsike clover hay, when processed in Sugar Jacks.

"*The Sugar Jack Mix.*—Standard Sugar Jack feed contains between 10 per cent and 11 per cent protein. Clover or alfalfa when combined with cornstalks or corn fodder, half and half, produces a mix containing about the same amount of protein as is obtained by following the advice of agricultural colleges in the combining of ensilage, hay and grain.

"Clover hay or alfalfa can be combined with corn fodder containing ears, in equal proportions. Some leading Sugar Jack users mix 60 per cent corn fodder with ears with 40 per cent clover hay or alfalfa. Where cornstalks are used the mix should be preferably half and half with clover or alfalfa.

"Pea vines or bean vines are almost equal to clover hay in the making of Sugar Jack feed. Cereal straws should never be used in greater amounts than one-third of a Sugar Jack mix, and while fed to dairy cattle, we do not advise this mix. However, it can be used as one-third ration in a satisfactory manner, to young cattle, as a maintenance ration, and when fed with vines and cornstalks, one-third each, is fed for fattening purposes.

"Sweet clover and cereal straws, when combined half and half make a ration containing about 11 per cent protein, and can be used as a dairy ration in a satisfactory manner, where the grain ration fed is largely carbohydrate, as for instance containing ground corn, oats, barley, and the like.

"One ton of Sugar Jack feed contains 10 pounds of Sugar Jack Converter, 790 pounds of roughage and 1,200 pounds of water. The converter is dissolved in the water and the converter solution used to dampen the roughage.

"The Sugar Jack process being a chemical process requires that the proper amount of Sugar Jack Converter be used with the proper amount of water, and the moisture applied uniformly through the roughage.

"*Moistening Roughage with Solution.*—Moisture is applied to the roughage either by dipping the roughage in a low tank containing the converter solution, on the mow floor near the top of the Sugar Jack Tube, and then pitching it in

the tube, or, by elevating the tank above the top of the press and using a hose and spray while tramping the roughage in the tube. The pressure of tramping holds the moisture if the feed is tramped immediately after the solution is applied.

"By the hose method, a layer of feed is placed in the press and then the feeder while tramping it down sprays the solution as evenly as possible over the layer; then fills in another layer and moistens this, etc.

"The dipping tank can be the same width or one foot wider than the tube, and two feet deep. Medium and small class farmers prefer to dip the roughage as the moisture can be more easily applied, but the larger class of feeders prefer the elevated tank with hose connections as in the larger barns there are usually two men available for filling the tubes, one to pitch in while the other moistens and tramps.

"The feed should be tramped regardless of which method is used to apply the moisture, as the pressure of tramping holds the moisture in the feed which would, otherwise, seep down through the feed to the bottom of the press; where the feed is dipped no water seeps through to the bottom of the press.

"A Sugar Jack Press is supplied for any number of livestock to be fed, but it is desirable that the capacity be larger than needed as the history of Sugar Jack shows that feeders invariably increase their live stock owing to the smaller amount of roughage which need be fed. It is safe to state that animals do not consume one-half of the roughage by this process which they consume by the old method of feeding, and that the average feeder increases his stock by 50 per cent during the first year he operates a Jack.

"In starting a Press, a smaller amount of moisture is used in the lower end if the moisture is applied with a hose. The press tube should be entirely filled and left for forty-eight hours on the start. Many farmers only desire to fill the upper end of the tube every other day, and a table of capacities is provided so that ample capacity may be provided for daily filling, or filling every other day. In warm months the tubes should be filled daily. Farmers who do not at all times obtain hot feeds need not be alarmed because during the first year presses are operated much of the feed used is cut before ripening period. After the first year, they learn from experience the advantages of cutting their roughage in a ripe or over ripe state, after which there is no trouble experienced in obtaining hot feeds in the coldest days of winter.

"A chemical process cannot operate to perfection unless the converter materials and water are in proper proportions. Care should be exercised to use one pound of converter to each 120 pounds of water, and to see that the moisture is equally distributed in the feed."

. . . . . .

"Fully 50 per cent of Sugar Jack roughage consists of by-products of the farm which cannot be processed in silos, such as dry cornstalks, clover threshings, vines, etc. The farmer sells the corn, seed, peas, beans, etc., which constitutes the primary crop, then uses the by-products converting them in to substantial sums of money. The labour must be charged to the primary crop and not to the by-products crop. In this manner farm labour is reduced.

"Farm labour is also reduced by the raising of roughage crops such as sweet clover and corn fodder, each of which yield prolificly with proportionately less labour than other crops. While it is true the cutting of roughage requires labour, yet this labour is more than offset by the use of the by-products and the crops which yield prolificly with little labour.

"Standard Sugar Jack Feed should contain from 10 per cent to 11 per cent protein, to be a balanced ration for dairy cattle. This ration can be obtained by using from 40 per cent to 50 per cent clover or ripe alfalfa; with from 50 per cent to 60 per corn fodder, or by using legume threshings in equal propor-

tions with corn fodder. Cornstalks are less valuable than corn fodder with the ears, but hundreds of feeders raise corn, sell the cereals, and feed the cornstalks with hay or hay threshings, and obtain a very satisfactory result."

" . . . . . .

"The Sugar Jack costs the feeder only about 15 per cent of the cost of a silo of equal capacity. The silo will not process dry by-products or dry primary products. All farmers fill their silos at about the same time, when labour is scarce, and at a high cost. The acid in the ensilage requires a large amount of other feeds to be fed to furnish proper subsistence for dairy cattle. The average dairy cow requires about 35 pounds of ensilage, from 20 to 25 pounds of hay, and one pound of grain for each 3.5 pounds of milk. A dairy cow fed on standard Sugar Jack, containing between 10 per cent and 11 per cent protein, requires but 14 pounds of Sugar Jack, dry weight, and much less grain, according to the condition and character of the cow. When this is considered with the fact that the Sugar Jack is largely made from by-products or crops which yield prolificly, the profits from the Sugar Jack process are accounted for.

"The pounds per hundredweight of crude protein and carbohydrates in roughage is given, taken from agricultural reports, to assist feeders in balancing their rations.

Roughage	Crude protein	Carbohydrates
Sweet clover	17·6	65·2
Alfalfa	17·4	64·2
Soybean	15·8	63·1
Red clover	13·6	63·2
Sorghum hay	9·5	73·4
Millet hay	8·8	70·3
Cornstalks	5·7	76·0
Corn stover	7·4	63·1
Timothy	6·8	72·6
Sudan grass	9·7	75·2
Red top	7·9	76·1

"All these roughages can be processed in a Sugar Jack Press, and it will be observed from the above list that the high protein roughages are sweet clover and alfalfa. Combined about half and half with cornstalks or corn fodder these make a well balanced ration.

"*Coarse Roughage.*—By means of the Sugar Jack process, the coarser roughages such as cornstalks, bean vines, pea vines, fodders, etc., are rendered edible and easily digestible.

"Sweet clover makes excellent Sugar Jack feed; contains more protein and yields more per acre than cereal feeds. It requires less labour to produce one acre of sweet clover yielding 5,000 to 8,000 pounds (dry weight, Ontario Bulletin No. 296), than to produce 1,500 pounds of cereal feeds. Sweet clover contains one-third more protein. Protein is the most valuable nutriment in feeds. Cereals require greater soil preparation, more labour in harvesting, threshing and grinding, involving much more time and expense than is required to grow and cut sweet clover."

. . . . . .

The foregoing is copied from the promoters' publication and is quoted simply as the most direct means of giving readers some idea of the process as advertised, and with no thought of lending strength to the claims therein made, through their appearing in the pages of a Departmental publication.

The foregoing "Sugar Jack" system of feeding was brought to the attention of and studied by the Animal Husbandry Division of the Central Experimental

Farm in the years 1923, 1924, and 1925. It was not felt, however, that investigation was warranted in view of the seemingly extravagant claims made and the apparently impractical nature of the process in its method of application. When, however, a laboratory was opened in Vittoria, Ont., and activities on the part of the promoters were commenced in the latter part of 1925 and early part of 1926, it was felt that experimental investigation of the process was highly desirable.

Before going into the matter, however, a survey was made of a few farms where "Sugar Jacks" were installed, in the vicinity of Vittoria in May, 1926, by a member of the Animal Husbandry Division. As a result of this survey, the practicability of the process was questioned. Nevertheless, arrangements were made for an installation. This was completed in the latter part of July, 1926.

A feeding trial comparing Sugar Jack processed feed with corn silage was begun immediately and extended over a period of six weeks. A second series of trials was conducted, starting in December, 1926, and continuing through to February, 1927. Both of these series of experiments were conducted jointly by the Animal Husbandry Division, the Division of Chemistry and the Division of Bacteriology of the Central Experimental Farm. Detailed reports on the respective phases of the work, as carried on by these divisions, are to be found in this publication.

For the benefit of those who have neither time or inclination to peruse these reports in detail, the results obtained may be briefly summarized as follows.

SUMMARY

1. In neither trial did the "processing" of the material add to or improve the nutritive value of the original roughage as judged by the results of the practical feeding tests, and by the chemical and bacteriological analyses.

2. In the preliminary feeding trial, the silage ration produced 8.9 per cent more milk and 6.2 per cent more fat than the Sugar Jack ration. In addition, the Sugar Jack ration was found to be much more expensive than the silage ration. In the second feeding trial, the silage ration produced 1.8 per cent more milk and 11.7 per cent more fat than the ration containing Sugar Jack. The production of milk and fat from the consumption of the unprocessed, dry roughage was equal to that from roughage of the same character, processed by the Sugar Jack system. Further, the dry roughage was equally palatable. The dry, unprocessed roughage ration plus a little molasses produced slightly more milk and fat than the same dry roughage put through the "Sugar Jack" process. In addition, in each case, in the second feeding trial the control rations proved decidedly more economical than the Sugar Jack ration.

3. In the "Sugar Jack" process, as in the ensiling of crops, there are chiefly two sorts or types of fermentation, the first leading to the loss of carbohydrates (starch, etc.) and the second leading to the destruction or breaking down of the proteins. This results in a loss of dry matter similar in character to that which takes place in the ordinary silo. The degree of loss will be determined by the nature of the original material, the moisture content of the processed material, temperature at time of processing, length of processing period, etc., etc., *i.e.*, by a number of factors, not all of which are under the operator's control.

4. The "Sugar Jack Converter", claimed to be the active principle in the process, was found, on analysis, to consist largely of common salt plus slaked lime and a little organic (vegetable) matter.

5. Warm water alone and warm water with common salt added to replace Sugar Jack Converter, proved to be as satisfactory in the processing as did the solution of the converter.

6. Difficulty was experienced in cold weather in starting the fermentation in the press and maintaining this uniformity, this in spite of the use of hot water at the start, and later on, the use of water with the chill removed, for mixing the converter.

7. An important, if not the most important consideration, is that of the amount of labour involved—the Sugar Jack system requiring much more labour than was necessary in feeding either the corn silage or the unprocessed rations.

8. It may be claimed that this process is in a state of evolution—that it may be likened to many modern standard farm operations, processes and machines, representing as they do, advanced developments of a more or less elementary idea. The Sugar Jack process, however, brings to light nothing novel or new, nor would it seem to be a progressive step in the preparation of farm roughages when compared with the silo.

9. Where roughage must be utilized, of poor quality and lacking in palatability, where a silo is not available, or where unbalanced or unsuitable rations, generally, are the rule—the Sugar Jack process might seem to offer certain advantages. On the other hand, this process is simply a development of an old fashioned method of feed preparation. This process was discontinued, in the great majority of cases, years ago, and this discontinuance was due to no other reason than that of the extra labour involved, as compared with (then) more modern systems of feed preparation, notably as made possible by the adoption of the silo.

SUGAR JACK FEEDING EXPERIMENTS

FIRST TRIAL

REPORT OF ANIMAL HUSBANDRY DIVISION

BY

George B. Rothwell, Dominion Animal Husbandman

AND

George W. Muir, Chief Assistant, Dominion Animal Husbandman

Briefly, the Sugar Jack system of feeding consists in processing rough feeds, such as clover threshings, timothy threshings, pea straw, bean straw, the cereal straws, corn stover, fodder corn, sweet clover hay, poor quality clover and alfalfa hays, etc. In the case of long feeds, chaffing or cutting is, of course, preferable. This material is then moistened either by sprinkling with or dipping in water containing a small percentage of a preparation called "Sugar Jack Converter", and finally the dampened material is filled and tramped into a species of miniature silo. The lower end of this silo is raised from off the ground, the upper end reaching through an opening into the barn floor. The material in the silo is kept from falling through the lower end by detachable cross bars. The size of the silo or press as available, varies with the probable size of the herd, being from three and a half to over six feet in diameter and some eight to twelve feet high. The moistened feed is kept in the silo for from forty-eight to seventy-two hours and is then fed out from the bottom, more being added at the top daily. In passing through the silo, the material reaches rather a high temperature, *i.e.*, up to and sometimes over 150° F. It is fed while still warm and moist.

At the commencement of the first feeding trials, the only feeds available for processing in the Sugar Jack press, were a quantity of wild grass hay and sweet clover hay, both of the 1925 crop. These were run through a cutting box, being mixed as evenly as possible, while they were being put through. This mixture was then bagged and held for the experiment, to be processed and the resulting material compared with silage. The experiment was run in three periods of two weeks each. The Sugar Jack processed feed was fed during the first and last periods and silage during the second or intermediate period. The data from the last week of each period only was used for computation of results, leaving the first week for a transition period. The results of the first and third period were averaged and compared with the results obtained in the second period, thus eliminating the factor of normal decline in milk flow.

The feeds were processed according to the instructions sent out with the outfit, and the results obtained, in so far as the action of the material in the press was concerned, were in accordance with the claims of the manufacturers. That is, the dampened material started fermenting and the whole mass reached a temperature of 150° F. at times, the greatest heat being in the centre of the press, the lower and upper portions, being exposed to the air, cooling off rather quickly. This warm material was fed to the cows as soon as it was taken out of the press. It should be stated, at this point, that the appearance and odour of the material as taken from the press, was at times, neither pleasant or appetizing. In appearance it was of a burnt brown colour and at times

there were traces of ammonia in the vapour which arose from it. To the casual observer, the material resembled nothing much more than a forkful as lifted from out a pile of thoroughly heated horse manure. A rather surprising feature was that in spite of the unpalatable appearance of the processed feed, the cows consumed it. It is to be noted, however, that they ate it under marked compulsion at first, nor did they, at any time, clean up their allowance with relish, as was the case with the silage fed. The cows were given thirty-five pounds of the processed feed daily, of which they left small portions at times. When corn silage was fed, they received only thirty-three pounds daily, all of which was cleaned up.

Table I following gives the results of the trial, while Table II shows the individual production of the cows on the test.

SUMMARY TABLE I.—FIRST TRIAL—SUGAR JACK PROCESS VERSUS CORN SILAGE

—		Period 1 — Sugar Jack	Period 2 — Corn Silage	Period 3 — Sugar Jack	Average Periods 1 and 3
Number of cows in test	No.	10	10	10	10
Duration of test	days	7	7	7	7
Pounds milk produced	lb.	2,169·50	2,352·50	2,119·00	2,144·25
Average per cent fat in milk	%	3·58	3·38	3·37	3·48
Total fat produced	lb.	77·70	79·46	71·41	74·55
Total meal consumed	"	826·00	826·00	826·00	826·00
Total hay consumed	"	700·00	700·00	700·00	700·00
Total silage consumed	"	.....	2,310 00	.....	.....
Total Sugar Jack consumed	"	2,450 00	.....	2,450·00	2,450·00
Silage consumed per 100 lbs. milk	"	.....	98·19	.....	.....
Sugar Jack consumed per 100 lbs. milk	"	112·92	.....	115·62	114·27
Cost of silage fed at $3.45 per ton	$	.....	3·98	.....	.....
Cost of throwing out silage—one man, 10 minutes daily at 35c. per hour	$	.....	0·41	.....	.....
Cost of Sugar Jack fed—					
1. Sugar Jack Converter at 6c. per lb	$	0·99	.....	0·94	0·965
2. Hay mixture at $8 per ton	$	4·60	.....	4·13	4·365
3. Cutting hay at $1 per ton	$	0·57	.....	0·51	0·54
4. Filling press—2 men, half hour daily five days per week at 35c. per hour	$	1·75	.....	1·75	1·75
Total cost of experimental feeds	$	7·91	4·39	7·33	7·62

TABLE II.—FIRST TRIAL—SUGAR JACK PROCESS VERSUS CORN SILAGE

SHOWING PRODUCTION OF INDIVIDUAL COWS DURING THE TEST

—	Period 1 — Sugar Jack			Period 2 — Corn Silage			Period 3 — Sugar Jack		
	Milk	Test	Fat	Milk	Test	Fat	Milk	Test	Fat
	lb.	p.c.	lb.	lb.	p.c.	lb.	lb.	p.c.	lb.
Sweet Echo	187·5	2·8	5·25	188·5	3·3	6·22	156·0	3·5	5·46
Grace Fayne Aaggie	145·5	5·0	7·27	144·0	3·4	4·90	107·5	3·2	3·42
Korndyke Bessie Ann	169·5	3·2	5·42	180·0	4·4	7·92	160·5	3·9	6·26
Ottawa Grace DeKol	172·5	3·9	6·73	181·0	3·8	6·88	171·5	4·0	6·86
Lyon Segis Bessie Ann	89·5	2·2	1·97	167·0	2·9	4·84	231·0	3·2	7·39
Leila Posch Mechthilde	251·5	3·3	8·30	287·5	3·2	9·20	300·0	3·5	10·50
Francy Oliva DeKol	328·5	3·8	12·48	331·0	3·0	9·93	258·0	2·9	8·50
Johanna Canary Maid	307·5	4·6	14·14	329·0	3·1	10·20	282·5	2·9	8·19
Ottawa Lula Posch	309·0	3·2	9·89	327·0	3·4	11·12	264·5	3·2	8·46
Zorra Hengerveld	208·5	3·0	6·25	217·0	3·8	8·25	187·5	3·4	6·37
	2,169·5	3·58	77·70	2,352·5	3·38	79·46	2,119·0	3·37	71·41

SECOND TRIAL

Sugar Jack Process Versus Corn Silage

This experiment was a further test of the Sugar Jack system of feeding commenced in August, 1926, with the object of obtaining additional data on the practical efficiency and economy of this system of feeding stock, particularly cattle, to which class of stock, if any, it seems best suited.

Seventeen cows were put on the experiment as follows:—

Lot 1.—Seven Holsteins fed Sugar Jack versus silage.

Lot 2.—Seven Ayrshires fed Sugar Jack versus same material fed dry in quantities sufficient to ensure their receiving an equal amount of the dry matter of the original material.

Lot 3.—Three Ayrshires and one Holstein fed Sugar Jack versus same material fed in quantities sufficient to ensure their receiving an equal amount of the dry matter of the original material but in this case the dry feed was dampened in the manger with a ten per cent molasses solution.

The following is the outline of the experiment in tabular form:—

—	Number and breed of cows	Period 1	Period 2	Period 3
Date.....	.....	Dec. 6–26	Dec. 27–Jan. 16	Jan. 17–Feb. 6
Lot 1.....	7 Holsteins.....	Sugar Jack—33–35 lb.	Silage—35 lb.	Sugar Jack—33–35 lb.
Lot 2.....	7 Ayrshires.....	Sugar Jack—30 lb.	Same feed fed dry in like quantity.	Sugar Jack—30 lb.
Lot 3.....	3 Ayrshires..... 1 Holstein	Sugar Jack—30 lb.	Same feed moistened with 10 p.c. molasses.	Sugar Jack—30 lb.

As will be seen, each period consisted of three weeks, allowing ample time for transition from one system of feeding to another before final data were taken, this being done only during the last week of each period. Again, by averaging the results of the first and third periods and comparing them with the results obtained in the second period, the natural decline in milk flow is eliminated.

The grain and dry long hay rations were determined at the start of the experiment and remained constant during the experiment.

The material processed in the Sugar Jack press consisted of a mixture in approximately equal parts by weight of cut corn fodder; cut hay—mostly clover and including rough sweet clover—and cut peas and oats hay, the latter harvested in rather too mature condition for a good quality of hay. This mixture was kept as constant in proportion and quality as it was possible to make it, i.e., each class of material was cut up separately and bagged, the bags holding approximately the same weight of each. One bag of each was dumped on the floor beside the press and the material was thoroughly mixed together by turning it over three times before it was put through the process.

This dry material, the Sugar Jack converter and the water used, were all weighed or measured into the press, and the resulting material, including the drip from the press, was weighed out.

The Sugar Jack press was handled according to the instructions of the manufacturers, with the exception *that warm water was used more often than it was stated to be necessary*, of which further statement will be made.

During the first filling of the press in this experiment, care was taken to accurately sample and weigh all material that went into the press until it was filled, then division boards were put in and everything coming out was weighed and sampled and later analyzed by the Division of Chemistry.

During the last week of each three week period,—composite samples of the material as going into and coming out of the press were taken for analysis by the Division of Chemistry. (See report of Division of Chemistry.)

The processed Sugar Jack material, the dry Sugar Jack material, the silage and the molasses fed to the different groups was each weighed in to them and a record kept of the amount fed and of the amount consumed by each group.

Records were kept of the milk production of each group, in seven day periods, throughout the whole experiment, so as to show the weekly rise or decline in milk flow. In addition, a butter-fat test was made over a period of four days, during the last week of each period, to determine the effect, if any, of the different feeds on fat production, as well as to ascertain the total fat production.

Owing to mishaps of one kind and another, three cows in Lot 1, one in Lot 2, and one in Lot 3, were, of necessity, deleted from the experiment, in order to make the results accurate. The following tables, therefore, are based on the results from four, six and three cows, respectively:—

TABLE I.—SECOND TRIAL —SUGAR JACK VERSUS CORN SILAGE, ETC.

MILK PRODUCTION

Name of Cow	Period 1					Period 2					Period 3				
	Dec. 6 to 12	Dec. 13 to 19	Dec. 20 to 26			Dec. 27 to Jan. 2	Jan. 3 to 9	Jan. 10 to Jan. 16			Jan. 17 to 23	Jan. 24 to 30	Jan. 31 to Feb. 6		
	Milk	Milk	Milk	Fat	Fat	Milk	Milk	Milk	Fat	Fat	Milk	Milk	Milk	Fat	Fat
	lb.	lb.	lb.	%	lb.	lb.	lb.	lb.	%	lb.	lb.	lb.	lb.	%	lb.
Lot 1—															
Joh. Keyes Helena	133·0	169·5	168·5	3·8	6·40	181·0	181·5	170·5	4·2	7·16	189·0	167·5	144·5	4·0	5·78
Fr. Oliva DeKol	173·0	170·5	155·5	2·8	4·35	163·0	148·0	135·5	3·2	4·34	132·5	122·5	112·5	3·4	3·82
L.S. Bessie Ann	196·0	196·0	187·5	2·8	5·25	153·0	171·5	163·5	3·5	5·72	165·5	146·5	149·0	2·9	4·32
Leila Posch Mech	157·5	150·5	129·0	2·9	3·74	124·0	114·5	111·5	3·2	3·57	110·5	108·5	96·0	3·2	3·07
Totals	659·5	686·5	640·5	3·08	19·74	631·0	615·5	581·0	3·58	20·79	597·5	545·0	502·0	3·38	16·99
Lot 2—															
Lillian of Oban	161·0	154·0	140·5	3·7	5·20	129·5	114·5	106·0	4·0	4·24	116·0	105·0	91·5	4·2	3·84
Fanny of Oban	113·0	102·5	83·0	4·0	3·32	82·0	81·5	72·0	4·0	2·88	60·0	47·0	26·0	3·7	0·96
Marjorie 10th	165·0	156·5	132·0	4·0	5·28	141·0	142·0	127·5	4·0	5·10	132·5	124·5	105·5	3·7	3·90
Ottawa Tilly	273·0	252·5	183·5	4·3	7·89	214·0	215·5	201·5	3·5	7·05	199·0	201·5	184·0	3·8	6·99
Allancroft Betsy	343·5	318·5	318·5	4·2	13·38	270·5	285·5	262·5	4·5	11·81	275·0	247·5	217·5	3·9	8·48
Maud 4th	317·5	315·0	300·0	3·9	11·70	263·5	234·0	220·5	4·4	9·70	230·0	216·5	191·5	4·6	8·81
Totals	1,373·0	1,299·0	1,157·5	4·04	46·77	1,100·5	1,073·0	990·0	4·12	40·78	1,012·5	942·0	816·0	4·04	32·98
Lot 3—															
St. Valentine's Pet	226·5	224·5	226·5	3·8	8·61	217·5	209·5	211·0	3·7	7·81	206·5	196·0	189·5	3·8	7·2
Korn. Ever. March	268·0	261·5	257·0	3·6	9·25	251·0	257·5	239·5	4·0	9·58	230·5	225·5	215·0	3·6	7·74
Ott. Victorine	241·0	230·5	220·0	4·6	10·12	217·0	208·0	194·0	4·4	8·54	199·0	181·0	165·0	4·4	7·26
Totals	735·5	716·5	703·5	3·98	27·98	685·5	675·0	644·5	4·02	25·93	636·0	602·5	569·5	3·90	22·20

SUMMARY TABLE II.—SECOND TRIAL—SUGAR JACK VS. CORN SILAGE

(Holstein Cows)

Nature of Experimental Ration	Period 1 — Sugar Jack	Period 2 — Corn Silage	Period 3 — Sugar Jack	Average Periods 1 and 3, Sugar Jack
Number of cows on test ..... No.	4	4	4	4
Duration of test ..... days	21	21	21	21
Milk produced first 7 days ..... lb.	659·5	631·0	597·5	628·0
Milk produced second 7 days ..... "	686·5	615·5	545·0	615·7
Milk produced last 7 days ..... "	640·5	581·0	502·0	571·2
Average percent fat last 7 days ..... p.c.	3·08	3·58	3·38	3·21
Total fat produced last 7 days ..... lb.	19·74	20·79	16·99	18·36
Total meal consumed last 7 days ..... "	259·00	259·00	259·00	259·00
Total hay consumed last 7 days ..... "	280·00	280·00	280·00	280·00
Total Sugar Jack fed last 7 days ..... "	997·00	.....	992·00	994·50
Average Sugar Jack fed per cow per day last 7 days ..... "	35·59	.....	35·43	35·51
Total Sugar Jack consumed last 7 days ..... "	898·00	.....	940·00	919·00
Average Sugar Jack consumed per cow per day ... "	32·07	.....	33·60	32·82
Total silage consumed last 7 days ..... "	.....	1,002·00	.....	.....
Average silage consumed per cow per day ..... "	.....	35·80	.....	.....
Dry matter in experimental roughage ..... p.c.	27·08	19·96	27·08	27·08
Dry matter consumed in experimental roughage per cow per day ..... lb	8·70	7·14	9·10	8·90

SUMMARY TABLE III.—SECOND TRIAL—SUGAR JACK VS. SAME FEED NOT PROCESSED

(Ayrshire Cows)

Nature of Experimental Ration	Period 1 — Sugar Jack	Period 2 — Same feed not processed	Period 3 — Sugar Jack	Average Periods 1 and 3 — Sugar Jack
Number of cows on test ..... No.	6	6	6	6
Duration of test ..... days	21	21	21	21
Milk produced first 7 days ..... lb.	1,373·0	1,100·5	1,012·5	1,192·7
Milk produced second 7 days ..... "	1,299·0	1,073·5	942·0	1,120·5
Milk produced last 7 days ..... "	1,157·0	990·0	816·0	986·5
Average per cent fat last 7 days ..... p.c.	4·04	4·12	4·04	4·04
Total fat produced last 7 days ..... lb.	46·77	40·78	32·98	39·87
Total meal consumed last 7 days ..... "	441·00	441·00	441·00	441·00
Total hay consumed last 7 days ..... "	357·00	357·00	357·00	357·00
Total Sugar Jack fed last 7 days ..... "	1,315·00	.....	1,048·00	1,181·50
Average Sugar Jack fed per cow per day last 7 days ..... "	31·30	.....	25·00	28·15
Total Sugar Jack consumed last 7 days ..... "	978·00	.....	960·00	969·00
Average Sugar Jack consumed per cow per day .. "	23·30	.....	22·85	23·08
Total dry feed fed last 7 days ..... "	.....	420·00	.....	.....
Average dry feed fed per cow per day last 7 days .. "	.....	10·00	.....	.....
Total dry feed consumed last 7 days ..... "	.....	400·00	.....	.....
Total dry feed consumed per cow per day last 7 days ..... "	.....	9·52	.....	.....
Dry matter in experimental roughage ..... p.c.	27·08	67·05	27·08	27·08
Dry matter consumed in experimental roughage per cow per day ..... lb.	6·30	6·37	6·23	6·30

SUMMARY TABLE IV.—SECOND TRIAL—SUGAR JACK VS. SAME FEED NOT PROCESSED BUT TREATED WITH 10 PER CENT MOLASSES SOLUTION

(Ayrshire and Holstein Cows)

Nature of Experimental Ration	Period 1 — Sugar Jack	Period 2 — Same feed not processed plus molasses	Period 3 — Sugar Jack	Average Periods 1 and 3 — Sugar Jack
Number of cows on test	3	3	3	3
Duration of test ..... days	21	21	21	21
Milk produced first 7 days ..... lb.	735·5	685·5	636·0	685·7
Milk produced second 7 days ..... "	716·5	675·5	602·5	659·5
Milk produced last 7 days ..... "	703·5	644·5	569·5	636·5
Average fat last 7 days ..... p.c.	3·98	4·02	3·9	3·94
Total fat produced last 7 days ..... lb.	27·98	25·93	22·20	25·09
Total meal consumed last 7 days ..... "	252·00	252·00	252·00	252·00
Total hay consumed last 7 days ..... "	189·00	189·00	189·00	189·00
Total Sugar Jack fed last 7 days ..... "	658·00	.....	621·00	639·50
Average Sugar Jack fed per cow per day ..... "	31·33	.....	29·57	30·45
Total Sugar Jack consumed last 7 days ..... "	546·00	.....	594·00	570·00
Average Sugar Jack consumed per cow per day ... "	26·00	.....	28·30	27·15
Total dry feed fed last 7 days ..... "	.....	210·00	.....	.....
Average dry feed fed per cow per day last 7 days .. "	.....	10·00	.....	.....
Total dry feed consumed per day last 7 days ..... "	.....	205·00	.....	.....
Total dry feed consumed per cow per day last 7 days ..... "	.....	9·75	.....	.....
Total molasses consumed per day last 7 days ..... "	.....	3·00	.....	.....
Total molasses consumed per cow per day last 7 days ..... "	.....	1·00	.....	.....
Dry matter in experimental roughage ..... p.c.	27·08	67·05	27·08	27·08
Dry matter in molasses ..... p.c.	.....	74·00	.....	.....
Dry matter consumed per cow per day ..... lb.	7·04	7·28	7·66	7·35

Before entering upon a discussion of the milk production phase of the experiment, some description of the practical operation of the Sugar Jack press would seem in order. Briefly, the instructions are to use one pound of Sugar Jack converter to twelve gallons of water, utilizing a large wooden tub as comprising part of the outfit, and employing warm or hot water for the first two or three fillings and thereafter, cold water. The mixed, cut feed is dipped into this solution, thoroughly wetted and then lifted out upon a slanted draining board, the upper end of which reaches the edge of the press, the lower end extending over the solution tub allowing the surplus solution to run back for further use. The material is pushed along this board until it falls into the press, filling one-third one day, another third the second day, and completing the filling the third day. The material put in the first day is supposedly ready to come out at 48 to 72 hours, depending on the season of the year (less time being required for the warm months), by which time it is supposed to have developed considerable heat—up to 150°F. Thereafter the process consists in adding as much material each day as will keep the press up to a certain level and yet not so full but that none of the material will be in the press for more than from 48 to 72 hours. It is claimed that with "roughage in ripe or overripe state, there is no trouble experienced in obtaining hot feeds in the coldest days of winter".

While theoretically the described procedure may appear entirely feasible—in actual practice (as in this experiment) it did not work out so well. In spite of using warm water at the start of the filling process and following this by the use of slightly warmed water almost continually thereafter, much difficulty was experienced in getting the material to process properly. According to the manufacturers, the material was not properly processed unless it came out "not only hot and moist but it also must be of a sticky nature" . . . "when the

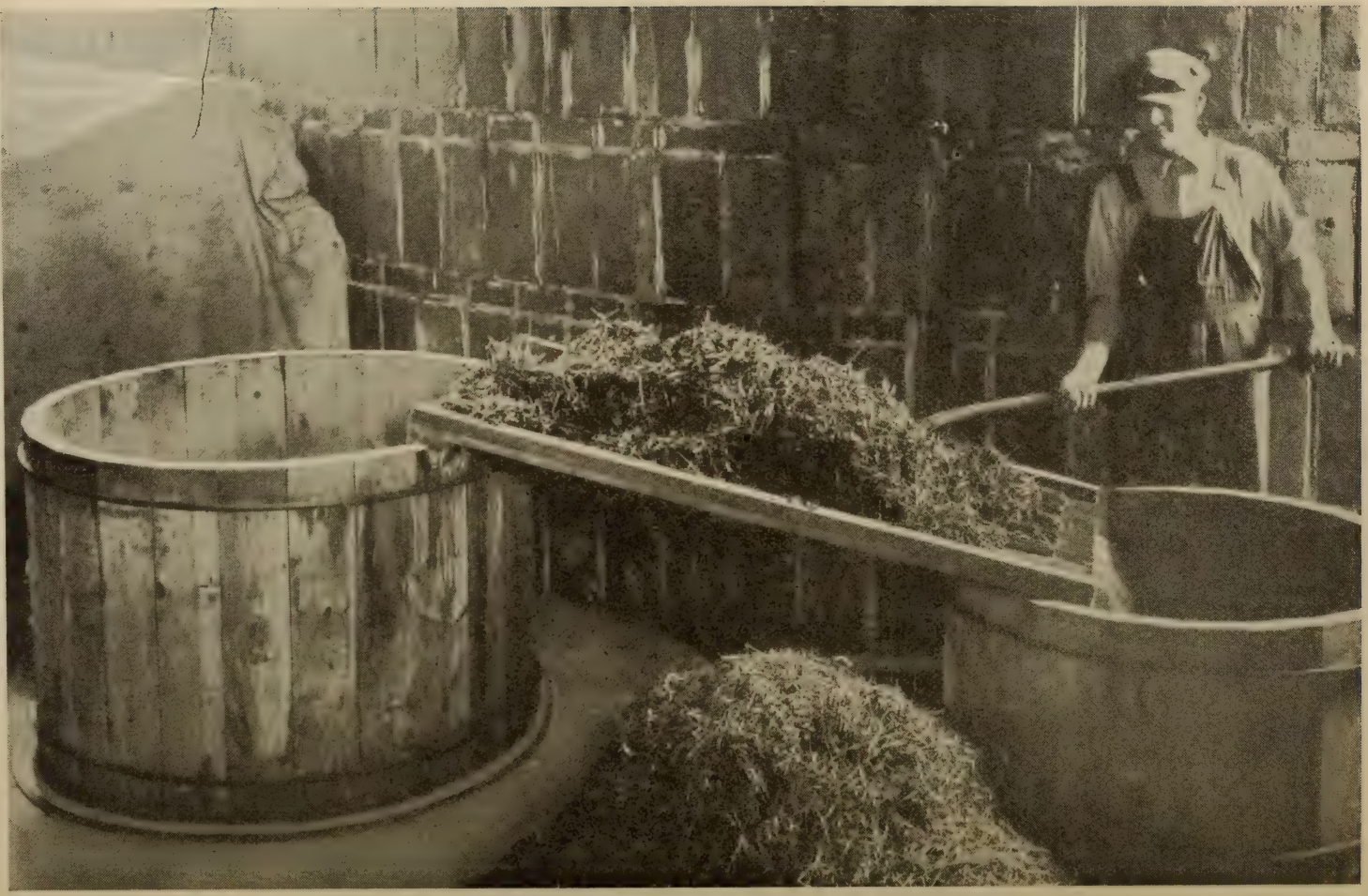
roughage fed has not this sticky nature, then it has not been properly processed, and the same beneficial results will not be obtained". In this connection, it was found that when the material in the press had reached the " sticky " stage, it was no longer palatable, but had come to the breaking down and destructive stage. This is borne out by the results obtained by the Divisions of Chemistry and Bacteriology. It was found that the cows relished the processed feed much more when it was thoroughly moistened and only slightly warmed through, than when it was processed to a greater degree. This is, after all, but in accord with good feeding practice, for, as already mentioned, previous to the advent of the silo, many good feeders followed the plan of chaffing hay and straw and mixing them with pulped roots and chopped fodder corn in a pile on the feeding floor, allowing the mass to stand until it had become uniformly moist and slightly warm. Good results were obtained, but, here note particularly, the mixture was not allowed to become so hot that the more readily available nutrients were broken down and destroyed. In the Sugar Jack Process when the hot, sticky stage was reached, the material was not palatable, to say the least, and had at times a strong odour of ammonia, showing that there was considerable breaking down, and therefore loss of protein. In addition to this undesirable nature of the fully processed material, there was the factor already mentioned, namely, the difficulty of controlling the process. Changes in the weather, the filling or the nature of the material used, would cause the material to be hot one day and cold the next.

In order that the process of fermentation be controlled in some measure, it would seem desirable that the press be installed at a point in the barn where it might be affected favourably by the stable warmth during cold weather. In the tests reported, it was impossible to locate the press elsewhere than in a comparatively cold feed room, a location which, it is not difficult to conceive, might be chosen of similar necessity in many barns.

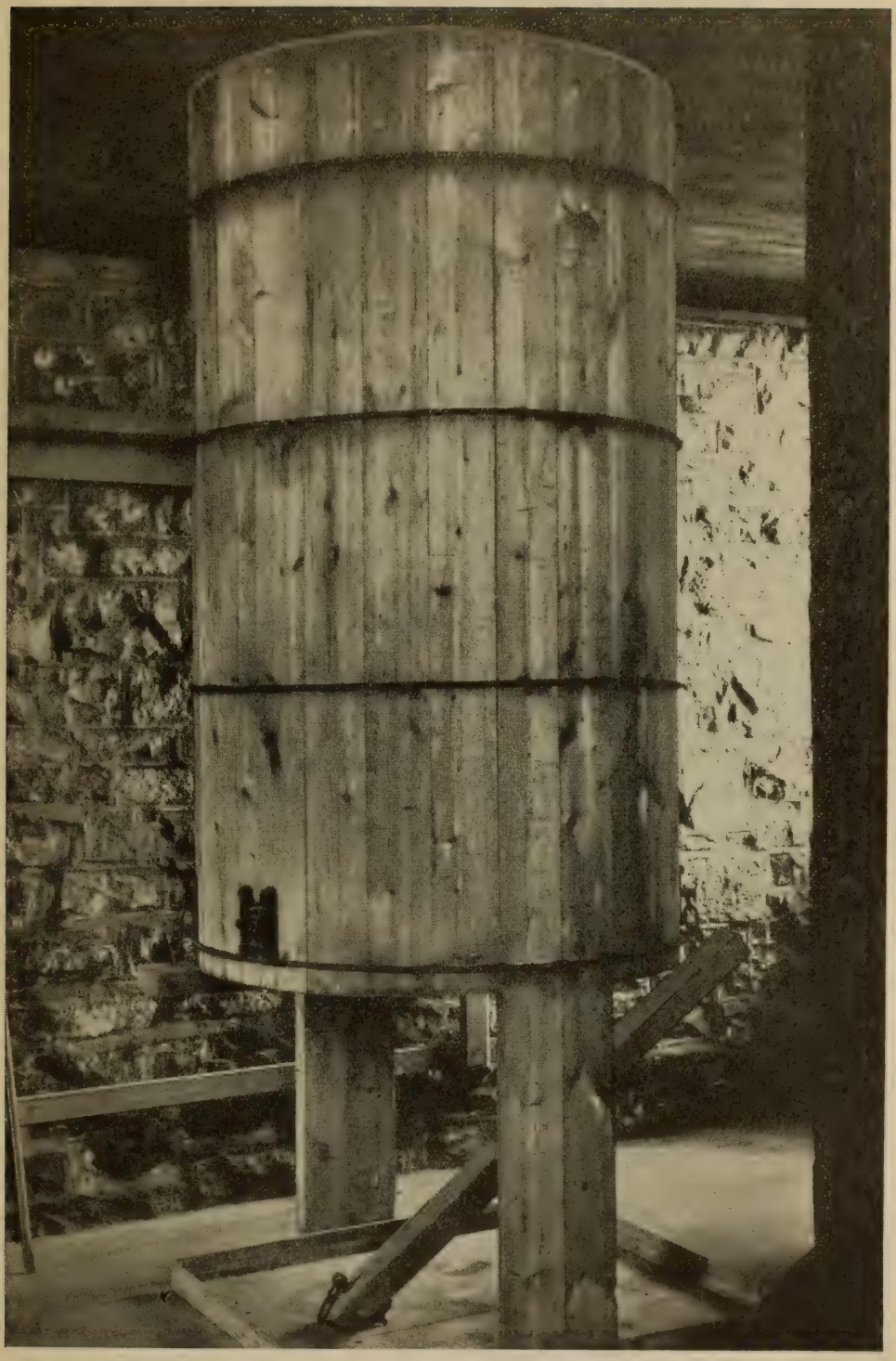
RESULTS FROM OPERATION OF SUGAR JACK PRESS

Dealing first with the actual results in milk and fat production from the feeding of Sugar Jack processed material in table I, it will be seen on comparing period two with the average periods of one and three that the corn silage ration produced slightly more milk and considerably more fat than the Sugar Jack ration. A glance at the last lines in this table will show that the Sugar Jack material contained considerably more dry matter than the corn silage, and a reference to table IV will show that the Sugar Jack material was of higher feeding value than the corn silage, which was particularly low in feeding value, due to being made in a very wet season from a more or less immature crop. Assuming that the dry matter in both feeds was equally digestible (even though the manufacturers claim super-digestibility for the Sugar Jack processed material) and keeping in mind that the cattle received practically equal quantities of the two feeds, it follows that the Sugar Jack processed ration supplied the greater amount of nutrients—it is interesting to note that it did not produce any more milk or fat than the silage ration.

In table II, comparing columns two and four, it will be noted that the ration of unprocessed material gave returns in milk and fat production slightly better in each case than the Sugar Jack processed material. Reference to the last lines in this table will show that the cows received equal quantities of dry matter in each ration. The results obtained would indicate that processing the material could not have improved its feeding value or there would have been a corresponding increase in the milk and fat production. It is to be noted in this phase of the experiment that the cows consumed a larger percentage of the unprocessed (dry) feed than they did of the Sugar Jack processed material, another indication that the palatability of the material was not increased.



Upper end of "Sugar Jack" press showing dipping tank in operation.



Lower end of "Sugar Jack" press.

In table III, comparing columns two and four, it will be noted that any differences in results during the last seven days of the experiment are in favour of the unprocessed feed plus molasses ration. Reference to the last lines in this table will show that each group of cows received practically equal quantities of dry matter daily. Here again the results would go to show that processing the feed by means of the Sugar Jack press did not add any more to its feeding value than treating the dry feed in the manger with a molasses solution did, and the latter method of preparing the feed cost considerably less in both time and money.

It will be of interest at this juncture to state that while full data for a fourth period were not obtained, nevertheless, the data for milk production during the third week of what would have been period four, when the cows all received silage, were worked up, and the results for periods two and four averaged and compared to period three, and in every case the milk production was higher when the control ration was being fed. This serves to act as a check on the accuracy of the figures reported.

The data as relating to milk and fat production would seem in conformity with the results obtained by the Divisions of Chemistry and Bacteriology, i.e., that processing these feeds by the "Sugar Jack" system did not make them any more valuable for milk production purposes. Such being the case, the inference would seem warranted that the only advantage of the Sugar Jack system of feeding might be in the *greater economy* of this system over recognized good feeding practices. Consequently the following paragraphs will deal with the subject from this angle.

ECONOMY OF SUGAR JACK PROCESS

The silage used in this experiment cost, in the silo ready for feeding, $2.85 per ton with a nineteen ton per acre crop. It might be well, however, to allow a cost of $4 per ton for average crops. To this, it would be necessary to add approximately thirty-five cents per ton for throwing the silage out of the silo ready for feeding, making a total cost for the silage of $4.35 per ton.

On the other hand, the material used in the Sugar Jack process cost as follows:—

Hay (mixed)	$ 8 37 per ton
Peas and oats hay (ripe)	8 50 per ton
Corn stover (same as corn silage)	4 00 per ton
Average	$ 6 48 per ton
Cutting above material	1 00 per ton
Sugar Jack Converter, 17 lb. at 6 cents per lb	1 02 per ton
Mixing and filling press	3 00 per ton
Total cost of dry material	$11 50 per ton

One ton of dry material equals 1.76 tons of processed material, consequently one ton of processed material would cost $6.52 or $2.17 more than corn silage. It is, therefore, fairly evident that on a comparison with silage Sugar Jack processed feed is not as economical as is silage.

A comparison on an economy basis with the same material fed dry, as in table II, shows a cost of $7.48 per ton for the dry material, containing 67 per cent dry matter as against $6.52 per ton for the processed material, containing only 27 per cent dry matter, making the dry matter in the Sugar Jack processed feed, over twice as expensive as that in the dry feed.

In the case of the ration containing dry feed plus molasses, the molasses added to the ration would raise the cost $1.14 per ton, making it $8.62 per ton, which, on a dry matter content basis, would still leave the dry cut feed treated with molasses, a more economical feed than the Sugar Jack processed feed.

Further, in feeding somewhat rough unpalatable roughage by treating it with molasses, it is not necessary to cut it, except possibly in the case of fodder corn. This would reduce considerably the cost of preparation. The cost in time and labour, of preparing and applying the molasses solution, is so small that it may be practically disregarded. A notable feature of this phase of the experiment, is that the palatability of the dry material treated with molasses was much improved over that of the same material either when fed dry or when Sugar Jack processed.

Objection may be taken, by some, to the results of this experiment on the grounds that the material processed was of too high quality and that, as a result, little improvement could be shown, and by others because of the fact that the Sugar Jack processed feed was used to replace a succulent feed in an already well balanced ration, instead of comparing it with a poorly balanced ration containing no succulence.

In anticipation of the first-mentioned possible objection, it is only necessary to point to the high fibre content (24.88 per cent) of the fresh material previous to processing as given in the report of the Chemistry Division, page 31, to see that there was considerable room for reduction of fibre. *Furthermore, the claims for the Sugar Jack system of feeding would seem to encourage or at least condone the production of poor quality fodders and roughages rather than to operate in favour of increased production of high quality feeds requiring no further outlay for special processing, in order that they be rendered palatable and productive.*

In answer to the second possible objection, the query may be made: if, as has been shown, the same results can be obtained more economically by the use of well balanced rations containing succulent feeds, would it not seem like "better business" to adopt such methods of cropping and feeding, than to improvise with a less efficient and more costly method such as the Sugar Jack system of feeding?

VALUE OF THE SUGAR JACK CONVERTER

It is of interest to note that in the first week of the last Sugar Jack feeding period, it was decided to test the value of the Sugar Jack converter by processing one lot of feed with warm water only, another lot with warm water and salt in the same proportions as the Sugar Jack converter, and a third lot with Sugar Jack converter in the regular way. The product from all three treatments was practically identical. All looked the same to the naked eye and were relished equally well by the cows. The observations, in the feeding trial, were borne out by analyses made of the same material treated in the three different ways, as will be seen on reference to the section of this report as prepared by the Division of Chemistry. The results were not surprising when it is noted that the Sugar Jack converter is essentially made up of salt and lime. (See report of Division of Chemistry.) The foregoing trials bear out the inference made previously, that equally good results might be obtained by mixing moist feeds on the feeding floor and allowing them to stand for a day before feeding. If coarse roughages require some treatment or process to make them more palatable, the use of molasses would seem to be recommended. Treatment of roughage with molasses is much cheaper than by Sugar Jack converter, and, in addition, molasses has the advantage of being a food in itself.

It will be observed from table I that the milk production was not nearly so high when Sugar Jack was fed as when corn silage was fed, even though the corn silage was not of the best quality.

It will also be observed that even when making conservative charges for the respective feeds and for the labour of preparing same up to time of feeding, the Sugar Jack feed is much the more expensive.

The following table shows the composition of the two feeds as fed to the cows:—

ANALYSIS OF SUGAR JACK AND CORN SILAGE

Nutrients	Sugar Jack — Average of two special and one composite sample	Corn Silage — Composite sample
	p.c.	p.c.
Moisture	62·05	77·45
Crude protein	3·93	2·23
Crude fat	1·39	0·51
Carbohydrates	14·32	7·73
Fibre	12·95	8·26
Ash	3·34	1·82

From the above, it will be seen that pound for pound the Sugar Jack contained the most nutrients. It was also fed in slightly larger quantities than the silage. It follows, therefore, that the Sugar Jack ration provided the most nutrients. The result, however, shows that the silage ration produced the most milk. The logical conclusion would seem to be that the Sugar Jack was less digestible, less palatable, and therefore inferior to corn silage as a dairy feed.

THE "SUGAR JACK" PROCESS

REPORT OF DIVISION OF CHEMISTRY

BY

Frank T. Shutt, M.A., D.Sc., Dominion Chemist

AND

S. N. Hamilton, B.A., Assistant Chemist

THE PROCESS: EQUIPMENT AND METHOD

This process is described in the advertisement of the company promoting this method of treating rough forages, as follows: "The Sugar Jack is a scientific system of preparing roughage such as hay, stalks, vines, straw, clover threshings etc. into an easily digestible state. Roughage considered valueless can now be converted into palatable feed which surpasses ensilage and selected, expensive hay."

The equipment necessary comprises (1) a "Sugar Jack Press" which may be better described as a stave tank or small silo, open at both ends and of the following varying dimensions, length 7 to 12 feet, diameter 4 to 7 feet. The lower end is partially closed by two or three stout cross bars which are held in position by hangers. By prying the supporting chain off the hanger one end of the bar is allowed to drop, permitting the material directly above the lowered bar to fall to the feeding floor.

This "press" or small silo, to facilitate filling, is set up and so placed in the barn that about one fourth of its length projects above the mow floor; the "clearance" or distance between the bottom of the silo and the feeding floor is from 3 to 4 feet, allowing ample room for handling and removing the "sugar jack". Though the "press" is secured to the mow floor, longer staves, opposite each other, and reaching to the feeding floor, help to support the weight of the filled silo.

(2) A "converter" or "dipping" tank. This is a tub or tank from 2 to 3 feet in diameter and 3 to 4 feet in depth placed on the mow floor near the mouth or open top of the silo. It is used to moisten or soak the roughage with the "Sugar Jack Converter", previously mixed with the requisite amount of water.

(3) A drainage board reaching from the top of the press to the top of the dipping tank serves for the return from the moistened roughage of the superfluous, unabsorbed "converter" liquid to the dipping tank.

The operation of making "Sugar Jack" may be briefly described as follows: To the "converter" fluid, made by mixing 1 pound of "Sugar Jack Converter" with 12 gallons of water in the "dipping" tank, roughage at the rate of 8 pounds of the cut dry feed to 1 gallon of liquid is added and the whole stirred until the roughage is thoroughly wetted. The wet roughage is removed from the tank by a hay fork and placed for a few minutes on the drainage board and then thrown into the press or silo.

As the material (the so-called Sugar Jack) is removed from the bottom, in sufficient quantities to meet the daily requirements, freshly treated roughage is added from the drainage board. The directions state that the material as fresh lots are added should be well tramped. The statement is made that after twenty-four hours in the press, the feed is ready for use. In practice, according to the amount daily used, it was found that the material was in the press from 48 to 72 hours.

COMPOSITION OF "CONVERTER"

The analysis, in the laboratories of the Division of Chemistry, of the Sugar Jack Converter, used in the first trial showed it to have the following approximate composition:—

Common salt	75 per cent
Slaked lime (Hydrated dolomitic lime)	23 per cent
Vegetable matter*	2 per cent

*A microscopic examination of this product by the Seed Branch, Department of Agriculture, revealed the presence of barley, barley hulls and chaff.

FIRST TRIAL

Plan of Experiments

The Division of Chemistry assisting the Division of Animal Husbandry in a feeding trial, undertook to make analyses of the roughages employed and the finished processed material.

An outline of the plan of experiment as conducted by the Animal Husbandry Division, is necessary to a clear understanding of the chemical results. It may be given as follows, there being three feeding periods, each of two weeks' duration:—

First period: Sugar jack.
Second period: Corn silage (with small admixture of sunflower).
Third period: Sugar jack.

The Sugar Jack, in the 1st and 3rd periods, and the silage in the 2nd period served as the succulent part of the ration, so that the comparison is to be regarded as strictly between the feeding value of the Sugar Jack and the corn silage.

The milk production of the second week in each period was taken as measuring the relative values of the compared feeds.

The milk production of the first and third periods were averaged and the result compared with that of the second period. This plan was adopted to allow for the natural decline in milk flow as the lactation period advances. These weights and their significance are discussed in the report on this enquiry by the Animal Husbandry Division.

The sampling of the roughages used, of the processed material (Sugar Jack) and of the corn silage may be outlined as follows:—

Nature of Roughage

The roughage used was a mixture of coarse hays, made up chiefly of June grass with more or less clover. In respect to condition or quality it might be considered of medium grade—not too coarse or harsh to be unpalatable, but rather too ripe and coarse to be first class. These were all cut fairly fine and well mixed. Samples of about 5 pounds each were taken daily during the second week of the first and third period at the refilling of the press and thus a composite was obtained representative of the roughage used for production of Sugar Jack in this experiment.

The analytical data indicate the presence of a certain proportion of legume hay; the material is decidedly richer in protein than hay exclusively of grasses. The percentage of fibre is somewhat high, confirming the impression gained from an inspection of the hay that this roughage is too ripe and coarse to be of first quality.

COMPOSITION OF ROUGHAGE, SUGAR JACK AND CORN SILAGE

Material	Lab'y. No.	Fresh material						Dry matter					
								Protein					
		Moisture	Crude protein	Crude fat	Carbohydrates	Fibre	Ash	Albuminoid	Non-albuminoid	Fat	Carbohydrates	Fibre	Ash
		p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.
Roughage (hay, grass and clover)	Composite	5·76	10·74	2·81	42·37	31·33	6·99	6·75	4·64	2·99	44·95	33·24	7·42
Sugar Jack, processed, 24 hours, 1st period	85838	66·53	4·23	1·23	13·39	11·61	3·01	7·09	5·55	3·68	39·98	34·72	8·98
Sugar Jack, processed, 24 hours, 1st period	85842	64·07	5·51	1·13	13·23	11·99	4·07	8·76	6·86	3·15	36·82	33·39	11·32
Sugar Jack, processed, 24 hours, 3rd period	Composite	65·76	4·52	1·34	14·16	11·39	2·84	7·30	5·92	3·91	41·26	33·29	8·32
Sugar Jack, processed, 48-72 hours, 1st period	85839	67·04	3·76	1·12	13·61	11·69	2·78	6·07	5·35	3·38	41·29	35·49	8·42
Sugar Jack, processed, 48-72 hours, 1st period	85843	56·49	4·61	1·79	16·36	16·49	4·26	5·86	4·74	4·11	37·61	37·90	9·78
Sugar Jack, processed, 48-72 hours, 3rd period	Composite	68·64	3·42	1·26	13·00	10·69	2·99	7·05	3·83	3·99	41·46	34·11	9·56
Corn Silage	Composite	77·45	2·23	0·51	7·73	8·26	1·82	6·65	3·22	2·26	43·14	36·64	8·09

Two collections of the processed material (Sugar Jack) were made during the second week of the first period. Each collection comprised two samples—one representative of materials which had been 24 hours in the press, the second that of material processed for 48 to 72 hours. The first was withdrawn after removal of material to a depth of, say 1 foot, the latter from the material as it was taken from the press for feeding. These four samples were analyzed separately.

During the third (and last) period samples were taken each day representing 24 and 48 to 72-hour material, respectively, and, after determining "total moisture" two composites for these respective ensiling periods were made for further analysis.

The corn silage fed during the last week of the second period was sampled daily and a composite made.

Fermentative Changes in the Press

The changes due to fermentation, as taking place in the press or silo, have been worked out in the Division of Bacteriology and are described and discussed in the report on Sugar Jack by the Dominion Agricultural Bacteriologist. Since this process is essentially one of fermentation the analytical data of the processed material (Sugar Jack) may advantageously be considered in the light of the bacteriological findings. The bacteriologist points out that the first stage is one leading to destruction of the carbohydrates—starch, sugar, etc.—with formation of organic acids, chiefly lactic acid. This takes place more particularly during the first twenty-four hours and in the material near the top of the silo. The second bacterial attack, resulting in a breaking down of the protein bodies with the producton of compounds of lower feeding value occurs chiefly in the older material, i.e., in that which has been in the silo from 48 to 72 hours, and therefore occupies the lower portion of the silo.

PROTEIN AND CARBOHYDRATES IN ROUGHAGE AND PROCESSED MATERIAL

(Calculated on dry matter basis)

Material	Protein	Carbohydrates
	p.c.	p.c.
Roughage	11·40	44·95
Sugar Jack processed 24 hours	12·62	39·98
	15·62	36·82
	13·22	41·26
Average	13·82	39·35
Processed 48–72 hours	11·42	41·29
	10·60	37·61
	10·88	41·46
Average	10·97	40·12

The Influence of Processing on Protein and Carbohydrate Content

The effect of the first stage of the fermentation is reflected in the higher protein and lower carbohydrates which characterize the dry matter of the material withdrawn from the top of the press (one foot under surface) after 24 hours, as compared with the original roughage. This is well shown by the figures given in the foregoing table. The average protein content of the 24 hours processed material is 2.42 per cent higher and the carbohydrates 5.60 per cent lower than the respective percentages for the roughage. Of course, this higher protein figure does not represent a gain; it results from loss or destruction or other constituents (carbohydrates), which necessarily leaves the dry matter smaller in amount but with a larger proportion of protein.

Partial breakdown of the nitrogenous portion of the fodder—crude protein—more particularly characterizes the changes brought about in the lower part of the press. This, when the press is in daily operation, means that the forage has been subjected to ensiling conditions for a period of 48 to 72 hours. This loss of protein as indicated by the researches of the bacteriologist is confirmed by the chemical data. The average percentage of protein in the dry matter for the three samples processed for 48 to 72 hours, is 10.97 as compared with 13.82 in the 24-hour material—a difference of 2.85 per cent. These results indicate a loss of practically 20 per cent of the protein—the most important nutrient in feeds.

To summarize the conclusions from the chemical data, the dry matter of the processed material taken from the bottom of the press and fed, as compared with the dry matter of the roughage used, is poorer in protein and carbohydrates.

With respect to the relative acidity of the Sugar Jack and the corn silage used in this experiment, the hydrogen ion concentration (pH) of the several samples is presented, as follows:—

	Hydrogen Ion Concentration (pH)
Sugar Jack, processed 24 hours	6·56
Sugar Jack, processed 48-72 hours	7·12
Corn Silage	3·67

The hydrogen iron concentration is a measure of active acidity; the figure 7 represents neutrality, numbers above 7, increasing alkalinity, below 7, increasing acidity.

These data show (1) that the 24-hour processed material (Sugar Jack) is very slightly acid, (2) that the 48-72 material is slightly alkaline and (3) that the corn silage is distinctly acid. In so far as they refer to the processed material, these results are in accord with those from the bacteriological and chemical work.

Salt Content of Sugar Jack

The first step in the processing of the cut roughage is the thorough moistening of the material with " converter water ". Since the " converter " is largely common salt it might be expected that the finished processed material, " Sugar Jack ", would have a considerable salt content. The following table presents the salt content of the roughage and of the several samples of processed Sugar Jack.

SALT CONTENT OF ROUGHAGE AND SUGAR JACK

Material	Common Salt	
	Fresh material	Dry matter
	p.c.	p.c.
Roughage	0·13	0·14
Sugar Jack 24 hours	0·24	0·73
" 24 hours	0·47	1·35
" 24 hours	0·47	1·39
" 48-72 hours	0·30	0·92
" 48-72 hours	0·38	0·88
" 48-72 hours	0·45	1·44

From these data it will be seen that the processed material (Sugar Jack) contains from one-quarter to one-half per cent of salt—an appreciable, though

not large, salt content. Very probably these figures indicate a percentage sufficiently high to give the material a slightly salty taste, which, if the case, would undoubtedly enhance palatability.

Composition of Corn Silage Used in This Experiment

The analysis of the corn silage used in this experiment—essentially corn with a slight admixture of sunflower—indicates a silage of good average quality. It is, however, somewhat high in fibre—an undesirable feature from the nutritive standpoint. For the purposes of comparison the following table presents the average composition of good corn silage—calculated from the analysis of eleven samples recently analyzed in the laboratories of the Division.

COMPOSITION OF CORN SILAGE

—	Corn Silage average of 11 samples	Corn Silage (with slight mixture of sunflowers) used for comparison in Sugar Jack experiment
	p.c.	p.c.
Moisture	76·89	77·45
Crude protein	2·14	2·23
" fat	0·79	0·51
Carbohydrates	12·16	9·73
Fibre	6·49	8·26
Ash	1·42	1·82
Acidity	2·65	2·74

SECOND TRIAL

First Series: Nature of Roughage and Plan of Experiment

In so far as the assistance of the Division of Chemistry has been concerned in this second trial of the Sugar Jack process, the work undertaken in the "first series" had chiefly in view the determination of the loss of organic matter (protein, carbohydrates, etc.), owing to the inevitable fermentative changes in the "press" or small silo.

The roughage used in this second trial consisted of clover hay, oats and peas hay and corn stover in equal proportions. The quality of the clover hay was fairly good, the oats and peas hay was somewhat too ripe and in consequence rather strawy. The corn stover was brought in from the field and held attached a considerable amount of ice and snow—which probably accounts in a large measure for the comparatively high moisture content of the cut mixed roughage.

In this trial the press was partially filled with treated roughage put in at intervals of 24 hours, the complete filling requiring three days. The bottom of the press had been previously packed to a depth of six inches with straw and covered loosely with slats. A partial partition of slats was laid on the roughage in the press after the third "filling", in order to mark the end of the weighed material.

The first lot of processed material was withdrawn on the third day (Dec. 8) from the first filling (Dec. 6)—approximately 50 hours. The second withdrawal was on Dec. 9, the third on the 10th, the fourth and fifth in the morning and afternoon respectively of the 11th, the sixth and seventh, similarly on the 12th, and the eighth and last on the morning of the 13th, the sixth day from the completion of the filling.

Weighings were carefully made of all roughage used and of all withdrawals of processed material. Representative samples of both, as well as of the "drip"

were taken for analysis. The analytical data obtained permit a comparison of the roughage and processed material in respect to composition and these data with the weights of material put in and withdrawn furnish the necessary figures for computing the losses of the several nutrients due to fermentation in the press.

ROUGHAGE AND PROCESSED MATERIAL

SUMMARIZED DATA

Roughage used, 1,172 lb., containing 703·1 lb. dry matter.
Processed material withdrawn, 2,560 lb., containing 646·9 lb. dry matter.
Drip 170 lb., containing 6·7 lb. dry matter.

DRY MATTER STATEMENT

Dry matter of forage put in press	703·1 lb.
Weight of (dry) "Converter" used	12·5 lb.
Total	715·6 lb.
Dry matter in "processed" material	646·9 lb.
Dry matter in drip	6·7 lb.
Total	653·6 lb.
Total loss of dry matter due to "processing"	62·0 lb.
Percentage loss of dry matter due to "processing"	8·8 %

Although every care was taken in this work the foregoing figures must be regarded as approximations and, further, it must be remembered they are from one trial only—and that from a process subject to many conditions of an extremely variable nature. They may however be safely regarded as repretative and such that the deduction may be made that the loss of dry matter by this method (Sugar Jack) is similar in character and degree to that in the ordinary silo.

The analysis of the Roughage mixture used and of the Processed material will permit a comparison of the two feeds in nutritive value and also indicate the nature of the changes in the press or sila and their effect on the composition of their dry matter.

ANALYSIS OF ROUGHAGE AND PROCESSED MATERIAL

Constituents	Roughage		Processed Material (Sugar Jack)	
	Fresh material	Dry matter	Fresh material	Dry matter
Moisture	40·02	.....	74·55	.....
Protein	6·11	10·19	2·76	10·78
Fat	2·19	3·66	0·79	3·04
Carbohydrates	25·00	43·25	10·47	41·69
Fibre	21·65	35·47	9·27	36·09
Ash	5·03	7·43	2·16	8·40
	100·00	100·00	100·00	100·00
*Albuminoids	5·48	9·34	2·53	9·87
Non-albuminoids	0·63	0·85	0·23	0·91

On the assumption that the dry matter in the roughage and in the processed material is of equal nutritive value, then, calculating from the above data, 1 pound of the roughage is the equivalent of 2.4 pounds of the processed material.

From these data and the weights of the roughage mixture and the processed material, the losses in weight in dry matter (and of its several constituents) due to fermentative changes in the press have been calculated. These results are set forth in the following table:—

LOSSES IN NUTRIENTS DUE TO PROCESSING

—	Dry matter	Protein			Ether extract	Carbo-hydrates	Fibre	Ash
		Albumin-oids	Non-albumin-oids	Total				
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
Roughage	703·1	65·8	5·8	71·6	25·6	304·1	249·5	52·3
Processed material	646·9	63·8	5·9	69·7	19·7	269·7	233·5	54·3
Losses	56·2*	2·0	.....	1·9	5·9	34·4	16·0	.....

* This figure represents the loss in weight of total nutrients when the dry matter of drip and converter is disregarded.

Discussion of Chemical Data

Comment on these data may be made as follows:—

The loss in protein is very small and certainly of no great significance. In the earlier trials a greater loss in this nutrient was observed. It is evident from the work to date that the changes taking place in the press are variable in character and degree. There are so many factors influencing fermentation—moisture, temperature, aeration, composition of the material, etc., all variable, that in no two trials could identical results be expected.

The "ether extract" in materials of this character (grasses, fodders, etc.) is not true fat but consists largely of the colouring matter (chlorophyl) gums, resins, etc., present in the fodder; the percentage of true oil or fat is really very small. With this in mind the loss here recorded—5.9 pounds, represents destruction of material of very much lower nutritive value than fat.

The chief loss, as was found in the previous trial, lies in the carbohydrates—starch, sugar and allied materials. This amounts to 34.4 pounds or 11.3 per cent of the carbohydrates originally present—a notable loss in a valuable nutrient.

The fibre is also attacked but the difference in percentage, comparing the dry matter of the roughage with that of the processed material, is not of any great significance.

The larger "ash" content in the processed material is due to the presence of a certain amount of the "converter" used in processing—a preparation which analysis has shown to consist essentially of salt and slaked (dolomitic) lime.

Salt Content of Processed Material

The analysis of the Sugar Jack Converter used in this trial showed it to have the following approximate composition:—

Common salt	73 per cent
Slaked lime (Hydrated dolomitic lime)	21 per cent
Organic (vegetable) matter	6 per cent

The salt content of the roughage and of the processed material has been determined as follows:—

—	Common salt	
	Fresh material	Dry matter
	per cent	per cent
Roughage	0·14	0·23
Processed material (Sugar Jack)	0·31	1·22

The salt content of the processed material is appreciable, due to the presence of a small amount of the converter. In all probability it imparts a

slightly salty flavour which enhances the palatability of the processed feed. The moist and warm condition of the material as taken from the press no doubt further commends it to the animal.

The work of the first series of this second trial of the Sugar Jack process has furnished results, which are in all important features, confirmatory of those of the first trial. Consequently the conclusions given in the previous report receive additional support. The data of the second trial are the more valuable in that they permit a quantitative review of the changes and losses occurring in this process.

Second Series: Nature of Roughage and Plan of Experiment

In this second series the composition of the roughage is compared with that of the processed product; losses by weight of the several nutrients, however, were not determined.

The roughage was made up of the same components, roughly in the same proportions, as in the first series. The sample analyzed was a composite and as representative as could be secured by the thorough mixing of portions of the material as fed into the press from Dec. 17 to 24, inclusive (Laby. No. 87707).

The processed material (Sugar Jack) was collected as twelve samples between December 19 and 26, and after determining their moisture content a composite was made for complete analysis. All the samples were taken from the bottom of the press and represent the material as fed for determination of milk yield.

COMPOSITION OF ROUGHAGE AND PROCESSED MATERIAL

Constituents	Roughage		Processed material (Sugar Jack)	
	Fresh material	Dry matter	Fresh material	Dry matter
Moisture	32·95	.....	72·92	.....
Protein	7·44	11·10	3·23	11·91
Fat	1·99	2·98	0·69	2·54
Carbohydrates	28·08	41·87	11·12	41·07
Fibre	24·88	37·11	9·45	34·91
Ash	4·66	6·84	2·59	9·57
	100·00	100·00	100·00	100·00
Albuminoids	6·10	9·10	2·77	10·22
Non-albuminoids	1·34	2·00	0·46	1·69

Assuming an equal digestibility of the roughage and the processed material, the data from this series would permit the inference that 1 pound of the former was approximately equal in feeding value to 2½ pounds of the latter.

A more detailed consideration of these data indicates the same general changes and losses observed in previous trials. There is, however, this additional feature that there has been a greater break-down of fibre. This is made evident by the fact that the percentage of fibre in the dry matter of the processed material is markedly lower than that of the roughage.

Third Series: Hot Water: Hot Salt Water Compared With Sugar Jack Converter

This series permits the close comparison, from the chemical standpoint, of the processed material, using for treatment of the roughage (*a*) hot water, (*b*) hot salt water and (*c*) Sugar Jack Converter. The roughage mixture employed for all three trials was of the same nature and composition.

In (*a*) and (*b*) the quantity of fluid used was at the same rate per hundred weight of roughage as that used when employing Sugar Jack Converter.

The salt solution was approximately of the same concentration as the converter fluid viz., 12.5 pounds to 150 gallons.

COMPOSITION OF ROUGHAGE AND PROCESSED MATERIAL

Treatment	Fresh Material							Dry matter					
	Moisture	Protein		Ether Extract	Carbo-hydrates	Fibre	Ash	Protein		Ether Extract	Carbo-hydrates	Fibre	Ash
		Albumin-oids	Non-albumin-oids					Albumin-oids	Non-albumin-oids				
Roughage (untreated).....	32·00	6·12	1·74	2·78	27·73	24·53	5·09	8·99	2·56	4·09	40·80	36·08	7·48
Material Processed with													
(a) Hot water.....	71·18	3·06	1·10	1·05	11·26	9·50	2·85	10·61	3·83	3·65	39·07	32·96	9·88
(b) Hot Salt Water.....	71·65	3·20	0·73	1·07	11·02	9·49	2·84	11·27	2·61	3·76	38·87	33·46	10·03
(c) Sugar Jack Converter.	66·53	3·77	0·63	0·90	14·15	10·62	3·40	11·26	1·89	2·69	42·26	31·74	10·16

It may first be observed that the changes already remarked in previous trials with the Sugar Jack process, namely, destruction of carbohydrates with consequent increase in the protein content of the dry matter, are to be noticed in all three cases. That is, that water alone and a solution of salt have brought about changes of the same nature in the press or small silo as the Sugar Jack Converter—which analysis has shown to be essentially salt and lime. The resulting processed material, in so far as the composition of its dry matter is concerned, shows the same general character.

The comparatively low water content of the processed material from the Sugar Jack Converter (*c*) approximates that found in the samples of the First Trial, viz., 65 to 68 per cent. The processed material of the first and second series of the Second Trial showed a much higher water content. From these results it may be concluded that the percentage of moisture in the processed material may fluctuate very considerably—the result of small differences in handling the material in the vat and on the drainage board.

Corn Silage Used in Second Trial

The corn silage used in the feeding experiments of this Second Trial was submitted to analysis, the following results being obtained from a composite sample composed of seven collections extending over a period of a week.

COMPOSITION OF CORN SILAGE

	Fresh material						Dry matter					
Moisture	Protein		Ether extract	Carbohydrates	Fibre	Ash	Protein		Ether Extract	Carbohydrates	Fibre	Ash
	Albds.	Non-Albds.					Albds.	Non-Albds.				
80·04	1·08	0·61	0·91	8·48	7·22	1·66	5·45	3·04	4·56	42·45	36·19	8·31

This corn silage is distinctly below the average in feeding value. Good corn silage from a sufficiently matured crop contains about 23 per cent dry matter, as compared with 20 per cent in this sample. Apart from this feature, and the fact that the fibre content is somewhat high this silage was of fair quality.

Comparing the *dry matter* of the Sugar Jack processed material with that of the corn silage, the former—by reason of its legume content—is decidedly the richer in protein.

SUMMARY AND CONCLUSIONS

The "Sugar Jack" plan of forage preparation is a short-period ensiling process; the fodder in passing through the press may occupy from one to three days according to the size of the equipment and the daily feed requirement.

As in all ensiling processes, fermentation takes place due to bacterial and chemical activities. This results in rise of temperature and a certain destruction of the nutrients—starch, sugar, protein, etc. According to the nature of the fermentation, either acidity or alkalinity may be developed.

In the Sugar Jack process, the action near the top of the press is one that results in loss of carbohydrates (sugar, starch, etc.) with development of acidity (lactic acid, chiefly). Lower down in the press, the older (48-72 hours) material has a tendency to become alkaline from formation of ammonia, resulting from breakdown of the crude protein. It may be safely concluded from the results of this enquiry that the losses due to fermentation in this Sugar Jack process are not less serious than in the ordinary silo; indeed, the condition of the material processed for the longer periods (say, over 48 hours) showed much more

"breakdown" and therefore greater loss of nutrients, than good corn or sunflower silage. It is, of course, absurd to expect that in passing through the press there can be any addition to the forage in nutrients.

Comparing the analytical data of the roughage with those of the processed material it will be seen that the dry matter during the processing lost approximately twenty per cent or one-fifth of its protein and twelve per cent or approximately one-eighth of its carbohydrates.

As a result of the Sugar Jack process a harsh coarse roughage may be presented to the animal in a moist, soft and warm condition. The slight saltiness imparted by the converter water may further enhance its palatability.

The question of palatability will be more particularly discussed in the report of the Dominion Animal Husbandman, but of this there can be no doubt that when the material has been too long in passing through the press, in other words when the fermentation processes have resulted in the production of a structureless mass, the Sugar Jack is decidedly offensive and quite non-edible. And in this connection it may not be out of place to add that science and experience alike have shown that when the dry roughage is palatable and of good quality its feeding value is not enhanced by submission to any ensiling process.

THE " SUGAR JACK " PROCESS

REPORT OF DIVISION OF BACTERIOLOGY

BY

A. Grant Lochhead, Ph.D., Dominion Agricultural Bacteriologist

INTRODUCTION

In connection with the series of feeding experiments conducted by the Division of Animal Husbandry on the " Sugar Jack " process of preparing cattle feed out of rough forages, microbiological tests were undertaken by the Division of Bacteriology with the object of gaining information concerning the nature of the fermentative changes occurring in the " silo " or " press " and the bacteria involved.

The equipment in connection with the process, the construction of the " press " and " dipping tank ", the preparation of the " converter solution " and the mode of treatment of the roughage used have already been described earlier in this bulletin and consequently need not be further detailed here.

SUGAR JACK CONVERTER

This whitish powdery material is represented as being an important factor in the process, being used for preparing a dipping solution with which the raw forage is moistened before being tramped into the press. It is not to be regarded as a culture in any sense, the material having been found to be practically free from bacteria. As reported by the Dominion Chemist, this material is composed almost entirely of salt and slaked lime. Its direct effect appears therefore to be chemical in influencing the composition and reaction of the material in the press and especially the liquid portion. It is thus of indirect effect upon the fermentative processes by regulating the types of micro-organisms causing breakdown of the material.

The chief properties of the converter appear to be its high salt content and its alkalinity, and from our observations we conclude that its function is twofold. By virtue of its salt content more plant material is brought into solution. In a special test equal quantities of cut hay, as used in the first trial of the process, were treated with equal amounts of tap-water, and tap-water plus 0.8 per cent salt respectively. This latter solution corresponds approximately to the strength of the converter solution when made up as directed. After five hours the salt solution had dissolved out 48 per cent more plant material than the water. This provides more material for the decomposition bacteria to work on. Furthermore, the salt and especially the alkaline ingredients of the material tend to check mould action. In the upper regions of the silo, the material is not packed as tightly as farther down, consequently air will have easier access to the mass. Mould growth, especially on material containing sugars, is greatly favoured by air, more particularly in the presence of acid, and one of the functions of the alkaline ingredients of the converter appears to be to prevent this mould development. In the interior of the silo, however, the exclusion of air is sufficient to check mould action, even though acids have developed. In this connection tests were made in jars in which cut hay was packed after being moistened with water, 0.8 per cent salt solution, and " Sugar Jack " converter solution respectively. Mould growth was greatest when water alone was used, considerably less with salt, and almost absent with " Sugar Jack " converter.

THE FERMENTATIONS IN THE PRESS

Two trials of the "Sugar Jack" process were made, the first in August and September, 1926; the second extending from December, 1926, to February, 1927. In the first trial the roughage used was a mixture of coarse hays, chiefly June grass with some timothy and sweet clover. For the second trial equal parts of stook corn, oat and pea hay (ripe) and mixed hays were used. During the course of these two trials samples for bacteriological analysis were removed from time to time from the press. Samples were taken as follows:—

(*a*) Material from the top of the press, representing freshly introduced material, or roughage freshly moistened with the converter liquid.

(*b*) Material which had been in the press approximately 24 hours, and which was partially changed, and represented an intermediate stage of the process.

(*c*) Material from the bottom of the press which represented fully processed material as fed to the cattle.

First Trial (First Series Feeding Experiments)

The first stage appeared to be essentially a carbohydrate fermentation in the course of which bacteria decompose the sugars with the formation of organic acids, chiefly lactic acid. Samples taken after approximately 24 hours showed a pronounced increase in the numbers of bacteria, particularly of acid-forming bacteria as compared with the fresh material (see table). As a result of the activity of these organisms, the original alkalinity, which is attributable to the alkaline reaction of the converter solution is reduced, and the reaction, at this intermediate stage of the process is more or less definitely acid in character. In the first trial the original pH value of approximately 7.8 was changed to acid values ranging from 6.7 to 5.4, individual samples taken on different days tending to show a certain degree of variation, as is always to be expected in a process of this nature. The initial stage, however, is one of acid production resulting from the breakdown of readily fermentable carbohydrates which is revealed by the large increase of acid producing bacteria. These findings are in accord with those of the Division of Chemistry. In the partially processed (24-hour) material, carbohydrates were found to be relatively lower, whereas protein was relatively higher than in the original material, indicating that the initial fermentation was primarily at the expense of the former.

In the first trial (August and September 1926), it was found that during the later stages of the process the carbohydrate fermentation became less prominent, while decomposition changes involving the nitrogenous constituents became more marked. The latter part of the process was characterized by the production of much heat to which was due, at least partly, the reduced bacterial content of the material taken from the bottom, compared with that from the middle. The numbers of bacteria capable of growth at high temperature (55° C.), the so-called thermophilic bacteria, were increased, many of these of the acid-forming type which help to complete the sugar fermentation. It is interesting to note that at this stage butyric acid is formed in appreciable amounts, whereas the production of this acid in the first stage is negligible. Butyric acid is essentially a product of the growth of bacteria which develop in the absence of air or oxygen, which organisms could be detected at this stage of the process.

That the nitrogenous components of the forage were subjected to decomposition at this latter stage was evidenced by the production of ammonia, not readily discernible in the earlier stages. As a result, the acid reaction of the 24-hour material was reduced until, at the bottom of the press it was generally found to be alkaline. At this stage free ammonia could be readily detected. The

change from a breakdown of carbohydrate towards one involving a decomposition of nitrogenous constituents is reflected in the notable decrease in the acid producing bacteria. This is again emphasized by the chemical analyses which show that in the final stage of the process the proteins rather than the carbohydrates are subject to loss.

Several bacteriological tests were made of the process during the first trial, which pointed to the same general trend of fermentation. Figures for a typical analysis are given in the following table.

SUGAR JACK PROCESS, BACTERIOLOGICAL ANALYSIS—(FIRST TRIAL)

—	Top (fresh material)	Middle (approx. 24 hours)	Bottom (approx. 48-72 hours)
Nutrient gelatine medium—			
Total count at 20° C	11,000,000	170,000,000	17,000,000
Dextrose agar medium—			
Total count at 37° C	2,600,000	117,000,000	19,000,000
Acid-forming bacteria	210,000	108,000,000	15,000,000
Per cent acid forming	8·1	92·3	81·5
Bacteria capable of growth at high temperature—			
Total count at 55° C	1,050,000	2,800,000	9,000,000
Acid-forming bacteria	0	0	8,500,000
Approximate numbers of bacteria as determined by dilution method, capable of fermenting different carbohydrates—		more than	
Numbers able to produce acid from dextrose	1,000,000	100,000,000	10,000,000
saccharose	1,000,000	50,000,000	1,000,000
xylose	100,000	1,000,000	100,000

Figures represent numbers of organisms per gram of moist material.

Second Trial (Second Series Feeding Experiments)

In the examination of the process during the second trial (December, 1926, to February, 1927), the same carbohydrate fermentation was observed which was evident in the previous trial. There were, however, some differences in the fermentation as a whole, due, apparently, to the nature of the roughage used, and also to the fact that the second trial was conducted in winter. The roughage used in this case had a moisture content of 40 per cent due to the wet condition of the corn fodder used, while in the first trial the moisture amounted to but 5.8 per cent. As a consequence of this comparatively high moisture percentage, the fresh roughage had a much higher original bacterial content.

In the second trial the carbohydrate fermentation, which represented the initial, and chief fermentation, continued longer, remaining more in the foreground even in the lower regions of the press. The acid-forming organisms remained at a high level throughout the process, reaching their maximum numbers towards the end of the process rather than at the intermediate stage as in the first trial. The decomposition of the nitrogenous compounds with attendant formation of ammonia, although noticeable to some extent, was less marked than in the course of the first trial made in the late summer. It was observed, in the winter trial, that on the whole, considerably less heat was evolved in the press than was noted in the summer test, which fact was probably associated with the tendency of the carbohydrate fermentation to lag until the final stage. The following table shows figures from a representative analysis.

SUGAR JACK PROCESS, BACTERIOLOGICAL ANALYSIS — (SECOND TRIAL)

—	Top (fresh material)	Middle (approx. 24 hours)	Bottom (approx. 48-72 hours)
Nutrient gelatine—			
Total count at 20° C	41,000,000	390,000,000	350,000,000
Dextrose agar—			
Total count at 37° C	25,000,000	125,000,000	360,000,000
Acid-forming bacteria	18,500,000	85,000,000	295,000,000
Per cent acid-forming	74·0	68·0	84·7
Bacteria capable of growth at high temperature—		less than	
Total count at 55° C	30,000	100,000	2,500,000
Acid-forming bacteria	5,000	.....	2,400,000
Approximate numbers of bacteria able to produce acid from			
dextrose	5,000,000	50,000,000	500,000,000
saccharose	5,000,000	10,000,000	50,000,000
xylose	500,000	10,000,000	10,000,000

Figures represent numbers of organisms per gram of moist material.

OBSERVATIONS

The process appears to be somewhat similar to that used in some European countries for the preparation of "brown hay" under damp conditions where it is not possible to cure hay properly in the sun. This damp hay heats up due to a combination of such activities as plant cell respiration, plant enzyme and bacterial action and an aromatic cattle feed is produced. With this method there is usually an appreciable decomposition of nitrogenous compounds with attendant formation of amides and ammonia. The preparation of "brown hay" is therefore characterized by a certain loss of nitrogen which tends to render it an uneconomical way of handling forage.

With the "Sugar Jack" Process, as is the case with all methods of silage preparation, the chief loss of food material results from the inevitable acid fermentation of the carbohydrates. As regards loss of nitrogen through decomposition of proteins, there would appear to be some danger in this direction, in case of any over-processing of pressed material. The final stages tend towards an ammoniacal, and consequently uneconomical, fermentation. Whether this stage will be reached within the regular process time will doubtless depend upon such factors as the composition of the material (more particularly the carbohydrate-protein ratio of the roughage), the extent of the carbohydrate fermentation and the temperature. Although the protein decomposition would be theoretically uneconomical yet the presence of certain of the by-products of this decomposition doubtless contributes to the characteristic aroma of the fully processed material.

PRINTED BY
F. A. ACLAND, KING'S PRINTER
OTTAWA, CANADA